ANCHOR-ICE.

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Articles have appeared in the May and August numbers of this *Journal* relating to the obstruction of the strainer of the inlet-pipe of the Detroit Water-works by ice in 25 feet depth of water. As suggested by Professor Henry, this is undoubtedly an example of *ground* or *anchor-ice*. Perhaps a brief account of some of the circumstances attending this curious phenomenon, in another place, may aid in elucidating the Detroit example.

The manufacturing establishments at Lowell are driven by water-power derived from a fall of about 34 feet at Pawtucket Falls in the Merrimack River. The dam at the head of the falls sets back the water about eighteen miles to the foot of the next fall above. Usually, before the middle of December, the entire reach of eighteen miles is frozen over. In ordinary stages of the river, nearly its whole flow is diverted into the canals by the dam, and is used by the manufacturing establishments. The current in most of these canals is too rapid to allow them to be frozen over. At times, the operation of the mills is seriously interrupted by anchor-ice, the formation of which is evidently connected with the open water, as at the mills which are supplied with water from the river through canals which are frozen over, there is no anchor-ice, while at others, supplied from the same source, through canals not frozen over, great trouble is experienced. In fact, it is uniformly observed that anchor-ice is found only at or below open water. The water is usually kept flowing through the canals during the night, when the mills are not in operation, passing over dams or weirs constructed for the purpose. During some part of most winter nights anchor-ice forms, and, in severe weather, men are employed through the night, in cutting it away from the tops of the dams, in order to prevent overflows.

Anchor-ice is an aggregation of small crystals or needles of ice, forming in the water a spongy mass, easily penetrated with any hard substance. It is frequently found adhering in large quantities to the bottom and sides of the water-courses, both open and covered. In clear weather, as the sun approaches the meridian, masses of anchor-ice often rise from the bottom of the open channels and float off, sometimes with earth and small stones adhering. It is produced in the greatest abundance in cold, clear, windy nights. It unquestionably originates at the surface of the water, the necessary conditions being, that the water should be at the freezing temperature, the air below that point and the surface of the water agitated, either by a current

or by the wind. In its first stage, the ice is in small detached needles or crystals; if there is little or no current, this ice accumulates at the surface and finally consolidates into a sheet; if the current is too strong to permit this, portions of it accumulate in spongy masses, and float along at or below the surface, their specific gravity differing but little from that of the water. In a current of water there is a constant intermixture of the water at different depths, producing a uniform temperature at all depths, and tending to distribute uniformly foreign matters held in suspension. This takes place even in the most uniform and regular channels. Natural water-courses are almost always irregular in form; the more irregular the more rapid will be the intermixture.

The anchor-ice being formed in small crystals at the surface, by means of this intermixture, much of that which does not aggregate in masses, is carried down from the surface, and is distributed throughout the whole depth of the stream, much in the same manner as earthy matters are carried along in suspension by currents. These crystals have a strong tendency to adhere to each other or to any other solid bodies they may come in contact with. The adherence can only take place by freezing, that is, by a new formation of ice, and here lies the mystery of anchor-ice. How can water become ice without a loss of heat?

Anchor-ice is observed to adhere to surfaces of stone or wood, over which the water is running with considerable velocity, in some cases exceeding 20 feet per second, growing up under this rapid current at the rate of an inch or more per hour. It is clearly not dependent upon radiation in the manner Dr. Wells has shown dew to be formed, for we find the piers of bridges and the interior surfaces of subterranean water-courses, where there can be no loss of heat by terrestrial radiation, covered with anchor-ice.

Faraday has shown, (*Glaciers of the Alps*, by J. Tyndall, page 351,) "that when two pieces of ice, with moistened surfaces, were placed in contact, they became cemented together by the freezing of the film of water between them, while, when the ice was below 32° Fahr., and therefore dry, no effect of the kind could be produced. The freezing was also found to take place under water; and, indeed, it occurs even when the water in which the ice is plunged is as hot as the hand can bear." It has been suggested that the union in these experiments is accomplished by a process analogous to the welding of metals. It might account for the adherence of the crystals of anchor-ice to each other, but not to other substances.

The following explanation of the process has been suggested. The formation of ice is a kind of crystallization, requiring time for its development. Anchor-ice commences to form at the surface of water, agitated either by a current or by the wind. The water being at the temperature of 32° Fahr., and the air at a lower temperature, heat passes from the water to the air, equivalent to the formation of a certain amount of ice; the water being agitated and the ice in minute crystals, the latter become mixed with the water before all the ice due

to the loss of heat is formed; and, although the crystals are removed from further loss of heat, they will continue to enlarge, until an equilibrium is attained. The amount of ice formed after the crystals leave the surface may be very small, but still be sufficient to cause them to adhere, when, by means of the current, they are brought in contact with each other, or with any other solid at the freezing temperature.

If this explanation is correct, the freezing process must continue for a considerable interval of time after the crystals leave the surface, as we have found, on drawing the water out of a subterranean water-course, the whole interior surface of the channel coated with anchor-ice, with great uniformity and symmetry, and several inches in thickness. This ice must have formed before it entered the subterranean channel and subsequently adhered.

Great inconvenience from anchor-ice is occasionally experienced at Lowell. It has been stated, that the dam there sets back the water about eighteen miles, forming a quiet reach of water usually frozen over early in the winter, which prevents the formation of anchor-ice on its surface. This ice is sometimes carried out, in the depth of winter, by a freshet. In December, 1863, this happened. On the 13th and 14th there were heavy rains, causing a rise in the river, which carried out the ice and discolored the water with earthy matter. In the night between the 15th and 16th, the wind was high from the north-west, anchor ice making freely with the thermometer at 30°. At 6 A.M., on the 16th, the wind was fresh and the thermometer at 26°, the anchor-ice forming very freely. The water-wheel for moving the sluice-gates of the Northern Canal could not be started, on account of anchor-ice having choked up the orifice through which the water is drawn. No anchor-ice is ever found at this wheel when the river is frozen over. The unusual amount of anchor-ice at this time, forming at such a high temperature, was attributed to the high wind and rapid current in the river, and the great extent of open water surface above the dams on which anchor-ice could form. Part of the anchor-ice thus formed passed into the canals, where it adhered to the sides of the water-courses and orifices, greatly obstructing the flow of the water. In such a case, the frozen surface of some of the canals is very little protection, as the anchor-ice made in the river becomes so thoroughly mixed with the water that it forms part of the stream at all depths, entering the canals with the water and flowing under the surface-ice. Strainers, used to prevent other substances than water from passing into orifices, are sometimes obstructed to such an extent that little or no water can pass through them.

The circumstances attending the formation of ice on the strainer of the Detroit Water-works do not appear to differ in any essential particular from that attending the formation of anchor-ice at Lowell. The depth of 25 feet, at which ice was formed at Detroit, is greater than it is found at Lowell, where none of the canals exceed 20 feet in depth, and are generally 10 feet or less. If, however, they were 25 feet deep, we should expect anchor-ice to gather at the bottom of them, pretty much as it does now, if the surface remained unfrozen.